are suffering from want of proper attention, and what is of even more importance his health is failing with over-application to work. There is no alternative but to relinquish his favourite hobby, and he parts with his books and instruments for what little they will fetch. How many are there who have had this experience? How many promising observers have left the science because it offers no pecuniary rewards or benefits such as other work commands? "Life is real, life is earnest"; the telescope must be neglected for the ploughshare, and the solitary though withal happy hours of vigil must be given over to Morpheus! Many have realised all this, and though their names will never be known as astronomers, they have deserved as much credit for their disinterested efforts as many others who have from more fortunate circumstances achieved eminence.

It must be admitted that observers of the present day have many advantages over their predecessors, owing to the greater perfection and size of instruments and the conspicuous advances in the serial literature of the science. The latter has developed wonderfully during the last few years with such publications as *The Observatory*, *Copernicus*, *L'Astronomie*, *Sirius*, *Ciel et Terre*, *The Sidereal Messenger*, &c. Formerly we had but the *Astronomische Nachrichten*, *Wochenschrift für Astronomie*, and *Astronomical Register*. This leads us to hope for a corresponding increase in the number of astronomical workers.

It cannot be questioned that the essential direction of labour on the part of amateurs should be more of a systematic or methodical character than hitherto. A certain department or definite work should be taken in hand and followed up persistently. Little good is likely to accrue from erratic work or from the hasty and necessarily incomplete examination of many different objects. Every observer has a leaning towards a speciality, and he should pursue this exclusively even to the absolute neglect of other departments. Astronomy offers such a large number and variety of objects that to attempt an investigation of more than a mere fragment will tax more than the energies of a lifetime. We would therefore recommend amateurs to apply themselves sedulously to such special branches as they may individually select, for the indiscriminate use of a telescope is to be deprecated on many grounds.

W. F. DENNING

ON THE NATURE OF INHIBITION, AND THE ACTION OF DRUGS UPON IT[1]

II.

M. VULPIAN has observed that the excitability of the lower parts of the spinal cord increases as the upper part is gradually shaved away, so that each layer of the cord appears to exercise an inhibitory action on the one below it. M. Brown-Séquard supposes that in each layer of the cerebro-spinal system there are both dynamogenic elements and inhibitory elements for the subjacent segments.

We are, in fact, almost obliged to assume that each nerve-cell has two others connected with it, one of which has the function of increasing, and the other that of restraining the function of the nerve-cell itself.

Applying this same hypothesis to Newton's rings, we would say that certain parts of the lens or of the glass plate possessed the property of interfering with the rays of light, or were inhibitory centres for them. Others again had the property of increasing the brightness, or were stimulating centres for them; and, moreover, that different parts of the lens or of the glass plate contained each its stimulating and inhibitory centres for different coloured rays.

The multiplication of centres in the lens and glass plate soon becomes more than the imagination can well take in; and we are at present almost precisely in the same condition regarding inhibitory and stimulating centres in the nervous system.

As soon as we get rid of the idea that the darkness caused by the interference of the rays of light at certain points is due to some peculiar property inherent in the glass, and attribute the interference simply to the relationship between the waves of light and the distance they have to travel, the whole thing becomes perfectly simple, and the same is, I think, the case in regard to inhibition in the nervous system.

Let us now take a few more examples of inhibition.

We find in experiments with the frog's foot exactly the same as on our own hand. Thus, when a little turpentine is placed upon the toes it excites a violent reflex, but if a little turpentine be injected under the skin of the same foot, the reflex is abolished.[1] We find also that irritation applied to a limited region of the skin usually causes marked reflex, but if the same stimulus be applied to the sensory nerve supplying that region, the reflex is very much less.[2] In the cases just mentioned the irritation is applied to sensory nerves of the same part of the body, and close together, and the explanation of its different results is the same as that already given for the different effects of tickling and pressure. Different sensory nerves on the same side of the body, but at some distance from each other, will also cause inhibition of motor reflexes; thus it has been shown by Schlosser[3] that simultaneous irritation of the skin over flexor and extensor surfaces will lessen reflex action.

Some years ago I observed that frogs suspended by the fore-arms with cords, or tied with their bodies against a board, reacted less perfectly to stimulation of the foot by acid than a frog suspended by a single point, as in Türck's method. Tarchanoff[4] has also observed that frogs held in the hand also respond less perfectly than when hung up; the gentle stimulation of the sensory nerves in the skin of the body appearing to exercise an inhibitory action over the reflex from the foot.

The injection of acids or irritating solutions into the mouth[5] or dorsal lymph sac[6] also exercises an inhibitory action on reflexes from the foot.

A similar effect is produced by irritating the sciatic nerve on one side by a Faradaic current, and applying a stimulus to the other foot. So long as the irritating current is passed through the sciatic nerve, no reflex movement can be elicited by stimulation of the other foot; but so soon as the Faradaic current stops, the reflex excitability again appears in the other foot.[7] As this phenomenon occurs when the influence of the brain and upper part of the spinal cord has been destroyed by a section through the cord itself, the inhibition which occurs must be due to an action which takes place in the lower portion of the spinal cord.

Stimulation of the nerves of special sense has also an inhibitory action on reflex movements. This we can readily see in ourselves, by observing our actions in the dark. If we touch something cold or wet, or if something suddenly comes against our face, we give an involuntary start, sometimes almost a convulsive one. If, however, we were able to see, we should not give a start in the least when we touched a piece of wet soap, or when the end of a curtain suddenly came against our cheek.

Without entering into the nervous mechanism through which sight effects this change in our actions, but only reducing it to its simplest form of expression, as we would in talking of animals, we say that the stimulus to the sensory nerves of the hand or cheek, by contact with the wet soap or with the curtain, caused in us a reflex spasm, which was inhibited by the stimulus applied to our optic nerves. A similar occurrence is observed in frogs, and the reflex actions produced by stimuli applied to the feet are much stronger when the inhibitory effect of the optic nerves upon them is removed by covering up or destroying the eyes, or by removal of the optic lobes.[1]

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[1] Continued from p. 422.

[1] Richet, Muscles et Nerfs, Paris, 1882, p. 710.

[2] Marshall Hall, Memoirs on the Nervous System, London, 1837, p. 48.

[3] Arch. of Physiol. 1880, p. 303, quoted by Richet, *op. cit.* 709.

[4] Quoted by Richet, *op. cit.* p. 709.

[5] Setschenow, Physiologische Studien über die Hemmungsmechanismen für die Reflexthätigkeit des Rückenmarks im Gehirn des Frosches, Berlin, 1863, p. 33.

[6] Brunton and Pardington, St. Bartholomew's Hospital Reports, 1876 p. 155.

[7] Nothnagel, Centralblatt d. med. Wiss. 1869, p. 211.

Regarding the optic lobes, we will have a good deal more to say presently, for they have been considered to be special inhibitory centres, and are often known by the name of Setschenow's centres.

If we try to explain all those instances of inhibition by the assumption of special inhibitory centres for each action, we must suppose, in connexion with every sensory nerve, that centres exist which lessen or abolish the ordinary reflexes produced by stronger or weaker stimulation applied to the nerve. Besides this, we must suppose other centres which inhibit motor actions in other parts of the body: as for example, when irritation of the extensor lessens reflex excited by irritation of the flexor surfaces, or *vice versâ*, or when the irritation of one sciatic stops reflex action from mechanical irritation of the other foot. A special inhibitory centre must be placed also in the optic lobes in connection with the optic nerves. This complication reminds us of the multitude of inhibitory centres which one must imagine in glass, in order to explain the occurrence of Newton's rings by them, but it seems to me that all these cases are readily explained on the hypothesis that the motor and sensory cells concerned in them are so placed with relation to each other that the stimuli passing from them produce interference *under normal or nearly normal conditions of the organism*.

A spot of light may be caused to disappear by throwing another ray upon it, so as to interfere with it, but it may be also made to disappear from the place where it was, by simply reflecting it somewhere else.

A similar occurrence to this takes place in the body, and although two stimuli may interfere with and destroy each other, we not unfrequently find that the apparent abolition of the effect of a stimulus is simply due to its diversion into some other than the usual channel. In very many cases, where we have inhibition we have also diversion; and it is not at all improbable that when the stimulus is very strong complete inhibition may be impossible by interference alone, and can only be effected by diversion of part of the stimulus. We have already said that two waves of sound will neutralise each other and produce silence, but this only occurs when the waves are not too powerful. When they reach a certain intensity they produce secondary waves which give resultant tones, and several facts seem to point to an analogous condition in animal organisms.

We have hitherto considered cases in which the inhibition was probably brought about by interference of two stimuli, so that the one counteracts the other in much the same way as two rays of light interfered with one another in Newton's rings. In one case which we have mentioned, the movement of the hand when it is tickled is entirely arrested by a strong effort of the will, and the hand is allowed to remain perfectly passive and limp. Here we suppose the impulse sent down from the motor centres in the brain to interfere with that which has originated in the cord by irritation of the sensory nerves, and to counteract it so that no muscle whatever is put in action. But very frequently we find that a result apparently similar is produced by a different mechanism, viz. by diversion of the stimulus into other channels. In the former case the arm is felt to be quite limp, but in the latter though it is quite quiet, it is perfectly rigid—all the muscles being intensely on the stretch. Here the stimulus which would usually have excited convulsive movements of the arm, and probably of the body, resulting in a convulsive start, have been diverted from the body into other muscles of the same limb.

A similar power of diverting a stimulus is seen in the instinctive muscular efforts which any one makes when in pain. One of the most common of these is clenching the teeth, and it used to be a common practice in the army and navy for men to put a bullet between the teeth when they were being flogged, and at the end of the punishment this was usually completely flattened. A patient seated in a dentist's chair usually grasps convulsively the arms of the chair, or anything which may be put into his hand; and there can be little doubt that pain is better borne, and appears to be less felt, when the sensory stimulus occasioning it can thus be diverted into motor channels. In children the motor channels into which diversion usually takes place are those connected with the respiratory system, and the sensory stimulus works itself off in loud yells. At a later age the stimulus is often diverted into those motor channels through which reaction occurs between the individual and his surroundings. Thus most people probably remember how a kick in the shins at football often served simply to accelerate their speed; and during the heat of battle the pain of a wound is often but little felt, the stimulus having been diverted into motor channels.

Many more instances might be given of the effects of diversion of stimuli, but having discussed this subject at length in a former paper,[1] I shall not pursue it further here.

Sensory stimuli are also capable of inhibition by interference. Hippocrates[2] noticed, and it is a matter of general observation, that pain in one part of the body may be lessened or removed by the occurrence of pain in another. In many instances, the removal of the pain to one part may be indirect, through the action exerted on the vessels by the pain in the other part. But in some instances it may be, and probably is, due to the direct interference of sensory impressions.

This question of the removal of pain by the interference of waves in the sensory nerves or nerve-centres has been very fully and clearly discussed by Dr. Mortimer Granville.[3] Starting from the hypothesis of interference, he has also devised a plan of treatment which appears to give satisfactory results. By means of a small hammer moved by clockwork or electricity, he percusses over the painful nerve in order to induce in it vibrations of a different rhythm to those which are already present and which give rise to the pain. Thus he percusses rapidly over a nerve when the pain is dull or grinding, and percusses slowly when the pain is acute, in order to produce interference if possible. In many instances the treatment is successful, and its success affords additional support to the hypothesis on which it is based.

We have hitherto spoken of reflex inhibition in the cerebro-spinal axis alone, but we find also reflex inhibition of motor actions produced by irritation of sympathetic nerves; and, *vice versâ*, we find inhibition of the movements of internal viscera produced by irritation of cerebro-spinal nerves. Thus strong irritation of the sensory nerves of the liver, intestine, uterus, kidney, or bladder, occasionally abolishes the power of walking or standing. Irritation of a sensory nerve will frequently arrest the movements of the heart.

The phenomena which occur in swallowing afford an excellent example, not only of inhibition occurring in parts innervated by the sympathetic system, but also of partial diversion of stimuli. Kronecker has found that when we swallow, the food or water is sent down at once into the stomach by the contraction of the muscles of the pharynx, and that afterwards a peristaltic contraction of the œsophagus occurs. When several attempts to swallow are made one after the other, however, the œsophagus remains quiet until they are ended, and then it occurs at the same interval of time after the last, that it would have done after a single act of swallowing.

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[1] Langendorff, Arch. f. Anat. u. Physiol. 1877; Von Boetticher, Ueber Reflexhemmung, Inaug. Diss., Jena, 1878, p. 12.

[1] Brunton, "Inhibition, Peripheral and Central," West Riding Asylum Reports, 1874.

[2] Hippocrates, Aphorisms, sec. i. 46; Sydenham Soc. Ed. vol. ii. p. 713.

[3] Mortimer Granville, Nerve Vibration and Excitation. (London: Churchill, 1883.)

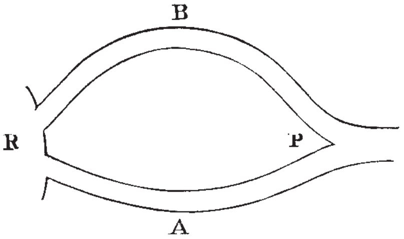

FIG. 2.—Diagram to illustrate Sir J. Herschel's observations on interference. Adapted from his article on "Absorption of Light," Phil. Mag. 1883, p. 405.

If we now refer again to our diagram (Fig. 2, which for convenience we repeat here) we will see that it answers just as well for the contractions of the œsophagus as for the tides at Batsha by simply giving a different meaning to the letters. Let R now instead of representing a reservoir or the open sea represent the ganglia of the pharynx, A and B the nerve fibres which conduct nervous impulses from these ganglia to P, and let P be the ganglia of the œsophagus which stimulate its muscular fibres to peristaltic action. A single wave passing from R causes two waves at P, one succeeding the other, but a number of waves from R under the conditions supposed also cause only two waves: one at the beginning and one at the end, for during all the intermediate period they neutralise each other.

It might perhaps seem that the two stimuli should cause two contractions of the muscular fibres of the œsophagus. But it frequently happens that a single stimulus is unable to produce muscular contraction. It only increases the excitability of the contractile tissue to a second stimulus, and when this is applied contraction ensues. The effect of the first wave then would be to increase excitability, that of the second wave to cause contraction. This is well shown in the accompanying tracing from the contractile tissue of medusæ, which I owe to the kindness of my friend, Mr. Romanes. He has found that when very slight stimuli, such as from weak Faradaic shocks, are applied, the first has no apparent action, but the effect of each successive stimulus is added to that of the preceding ones, until contraction is produced. Two shocks were applied before the first small contraction shown in the tracing occurred, and the shocks are all of the same strength, although the last ones produce the maximal contraction of which the tissue is capable, and the first had apparently no effect at all. This relation of the contractile tissue to stimuli is usually expressed by saying that the tissue has the power of summation.

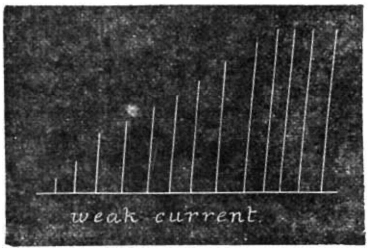

FIG. 6.—Showing the increasing contractions of the tissue of medusa when stimulated by repeated weak induction shocks of the same intensity.

At the same time that a stimulus is sent down from the pharynx to the œsophageal ganglia, which has an inhibitory action, there appears to be another sent to the medulla oblongata, which acts on the roots of the vagus nerve. This latter stimulus has a very curious effect, viz. inhibition of inhibition. The vagus usually exercises an inhibitory action on the heart, rendering its beats less rapid than they would otherwise be, but during swallowing this inhibitory action is removed and the heart pulsates at nearly double its normal rate.[1] Here we seem to have a stimulus one part of which passes along one path, while another part is diverted and passes along another. Each part interferes with the nervous actions which would occur in its absence, but one part interferes so as to prevent, and the other so as to increase muscular activity in the œsophagus and heart respectively.

The same diversion of a stimulus which we find in the case of the œsophagus seems to occur frequently throughout the body. Thus we find it almost invariably in relation to the vascular changes which occur on stimulation of a sensory nerve. When a sensory nerve going to any part of the body is irritated, the vessels of the district which it supplies usually dilate, while those of the other parts of the body contract.[2] The stimulus in this case passes to the vasomotor centre, and thence is reflected as an inhibitory stimulus in one direction and as a motor stimulus in another.

Some results of the greatest interest have recently been obtained by Dastre and Morat, in some experiments which they have made on the subject of vascular dilatation or inhibition.

In many cases the stimulation and inhibition of vascular nerves take place in the medulla oblongata, or in the spinal cord, and the inhibitory and motor centres are close to each other; but in other cases, such as those experimented on by Dastre and Morat,[3] we find the inhibitory and motor centres separated from one another, some of the motor centres being in the cord and some of the inhibitory in a ganglion situated nearer the periphery.

It was previously known that in some cases, as in the dilatation of the vessels of the submaxillary gland on irritation of the chorda tympani, small ganglionic structures were situated at the terminal branches of the nerve, and it was supposed that these ganglia, by their interposition between the nerve and the structure on which it was to act, converted its motor power into an inhibitory one. The experiments of Dastre and Morat are much more definite on this point. Excitation of the cervical sympathetic nerve has the effect of causing the vessels of the ear to contract very greatly in the rabbit, but irritation of the same nerve causes in the dog enormous dilatation of the vessels of the mouth. Moreover, in the rabbit this constricting action on the vessels of the ear is exerted only when the nerve is irritated between the first cervical ganglion and the ear. When the nerve is irritated beyond the cervical ganglion, instead of causing constriction, it produces dilatation.

In order to explain this action, the authors suppose that the fibres of the sympathetic, in passing through the ganglion, end in the ganglionic cells, and thus suspend the tonic action which they exert on the constricting fibres which issue from the ganglion and pass to the ear. It seems to me, however, that a more satisfactory explanation of this fact also is afforded by the hypothesis of interference.

In the cerebro-spinal system, cells being ranged above, below, and around one another with free communication between them, we have ample provision for the passage of two stimuli along paths of such different length, as to enable them to interfere with and inhibit each other.

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[1] In my own case the proportion is 120 to 76.

[2] Ludwig and Loven, Ludwig's Arbeiten, 1866, p. 17.

[3] Archives de Physiologie, 1882, tom. x. p. 326.

But in peripheral nervous mechanisms, such as those in the heart of the frog, where we have no such provision, and the cells are not only few in number, but not arranged in strata, we find a special form of ganglion cell which seems constructed for this very purpose. This is the spiral cell described by Beale, in which we find one nerve-fibre twisted round and round in a way which reminds us of a resistance coil in a galvanic circuit. The object of this peculiar arrangement has, so far as I know, not been discovered; but it seems to afford the exact mechanism which is wanted, in order to alter the distance two stimuli have to travel, and thus allow them to interfere with and inhibit each other. The occurrence of these ganglia in the heart and other viscera seems to afford in itself some support to the hypothesis here advanced; but we will defer the consideration of the mode in which inhibition occurs in the heart and other internal viscera, and pass on at present to the effect of various parts of the central cerebro-spinal system upon each other.

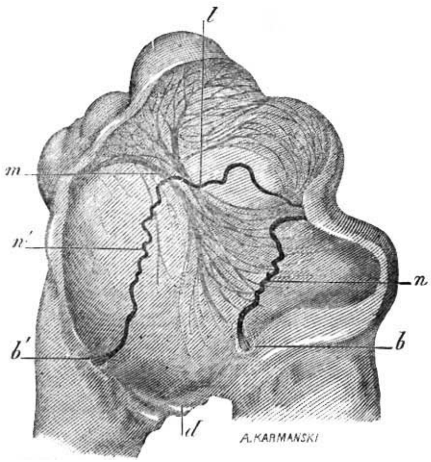

FIG. 7.—View of the auricular septum in the frog (seen from the left side). *n* is the posterior, and *n'* the anterior cardiac nerve, *t* is a horizontal portion of the latter nerve; *b* is the posterior, and *b'* the anterior auriculo-ventricular ganglion; *m* is a projecting muscular fold. This figure is taken by the kind permission of my friend, M. Ranvier, from his Leçons d'Anatomie Générale, Année 1877-8.—Appareils nerveux terminaux, t. 6, p. 79. (Paris: J. B. Baillière et Fils, Rue Hautefeuille 19.)

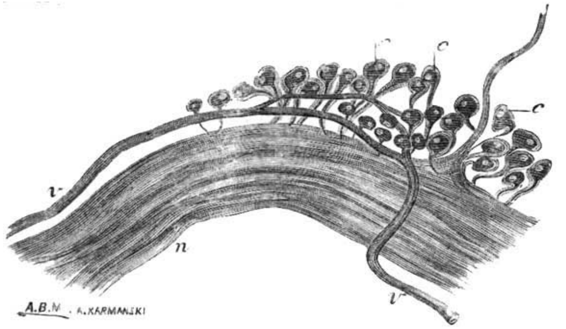

FIG. 8.—Part of the posterior cardiac nerve more highly magnified, showing the ganglia (Ranvier, *op. cit.* p. 106).

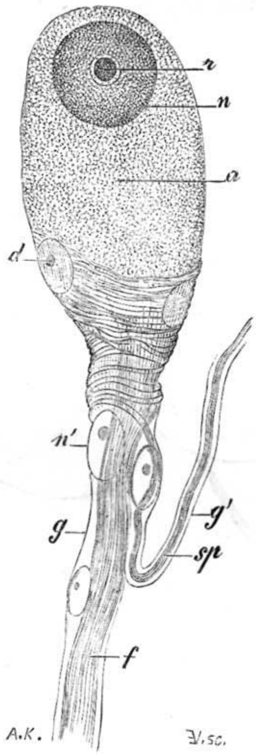

FIG. 9.—Spiral ganglion cell from the pneumogastric of the frog. This figure is not taken from the cells in the cardiac nerves, as in them the connection between the spiral and straight fibres has not been clearly made out, but it is probable that these cells have a structure similar to the one figured (Ranvier, *op. cit.* pp. 114-20). *a* is the cell body, *n* the nucleus, *r* the nucleolus, *d* nucleus of the capsule, *f* the straight fibre, *g* Henle's sheath, *sf* spiral fibre, *g'* its gaine, *n'* nucleus of Henle's sheath (Ranvier, *op. cit.* p. 114).

T. LAUDER BRUNTON

(*To be continued.*)

THE SHAPES OF LEAVES

I.—*General Principles*

THE leaf is the essential and really active part of the ordinary vegetal organism: it is at once the mouth, the stomach, the heart, the lungs, and the whole vital mechanism of the entire plant. Indeed, from the strictest biological point of view every leaf must be regarded as to some extent an individual organism by itself, and the tree or the herb must be looked upon as an aggregate or colony of such separate units bound together much in the same way as a group of coral polypes or the separate parts of a sponge in the animal world. It is curious, therefore, that so little attention, comparatively speaking, should have been given to the shapes of the foliage in various plants. "The causes which have led to the different forms of leaves,'' says Sir John Lubbock, "have been, so far as I know, explained in very few cases." Yet the origin of so many beautiful and varied natural shapes is surely worth a little consideration from the evolutionary botanist at the present day, the more so as the main principles which must guide him in his search after their causes are simple and patent to every inquirer.

The great function of a leaf is the absorption of carbonic acid from the air, and its deoxidation under the influence of sunlight. From the free carbon thus obtained, together with the hydrogen liberated from the water in the sap, the plant manufactures the hydro-carbons which form the mass of its various tissues. Vegetal life in the true or green plant consists merely in such deoxidation of carbonic acid and water, and rearrangement of their atoms in new forms, implying the reception of external energy; and this external energy is supplied by sunlight. We have thus two main conditions affecting